Let's C what we can do:
Reversing energy emissions scalably with atmospheric CO_2 to solid-phase carbon

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ARPA-E Fellow

ARPA-E Energy Innovation Summit – Denver, CO – Tuesday, May 24th, 2022

Natural cycles took carbon out of the atmosphere over millions of years. Humans have been undoing it for 300 years to extract energy.

Volume of fossil fuels we've burned since 1850 (oil equivalents, equals 1,600 Gt CO_2)

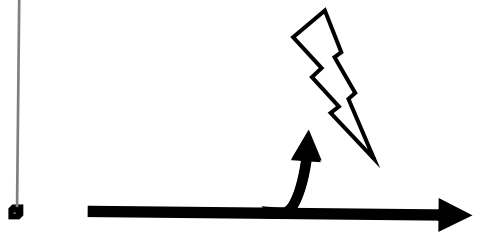
$(6x10^{11}\ m^3)$

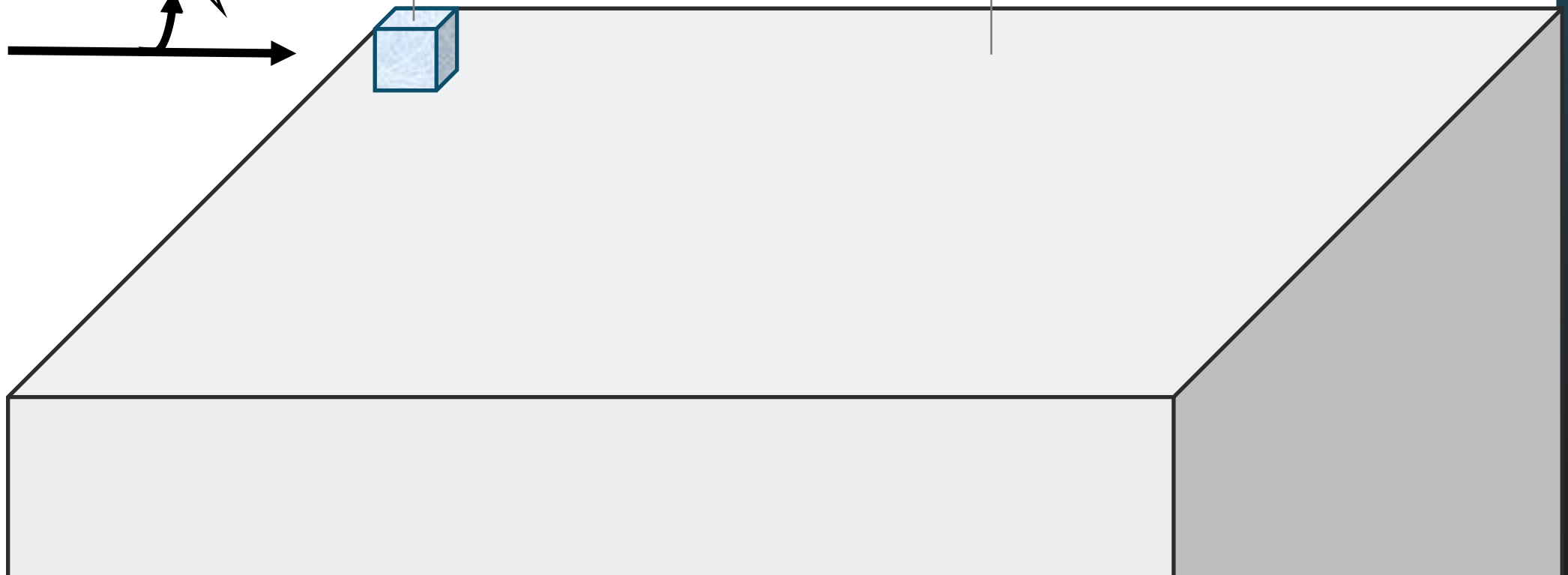
Volume of pure CO_2 from fossil fuels (1 atm, 25°C)

$(9x10^{14}\ m^3)$

Volume of atmosphere

$(6x10^{18}\ m^3)$





Friedlingstein *et al.*, 2019. https://doi.org/10.5194/essd-11-1783-2019

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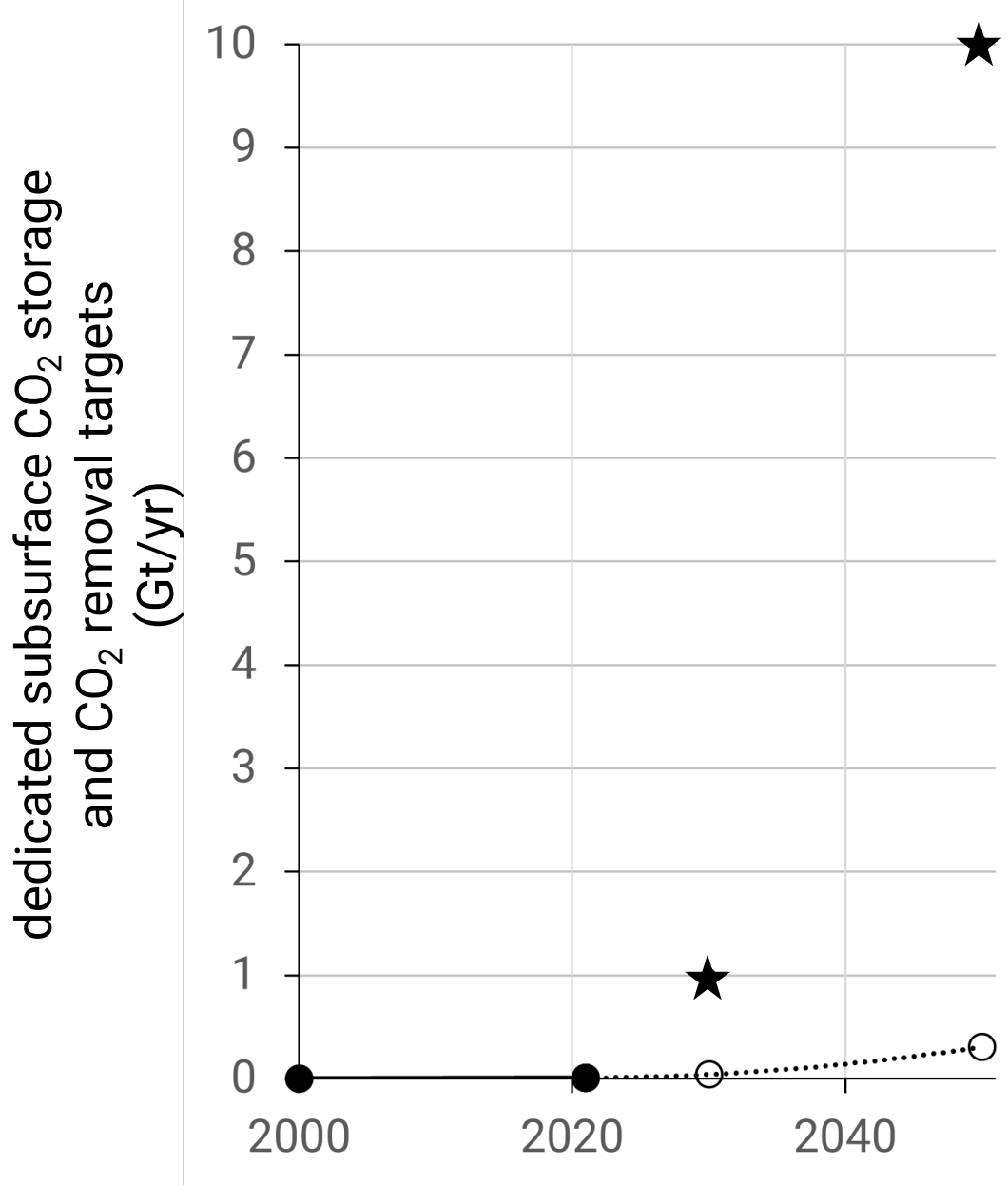
As we scale carbon removal, we must also scale carbon storage.



Key:

★ CO_2 removal targets

● dedicated subsurface CO_2 storage, to date

○ dedicated subsurface CO_2 storage, projected

Estimates and future scenarios based on:

Martin-Roberts *et al.*, 2021. https://doi.org/10.1016/j.oneear.2021.10.002

National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda, 2019.

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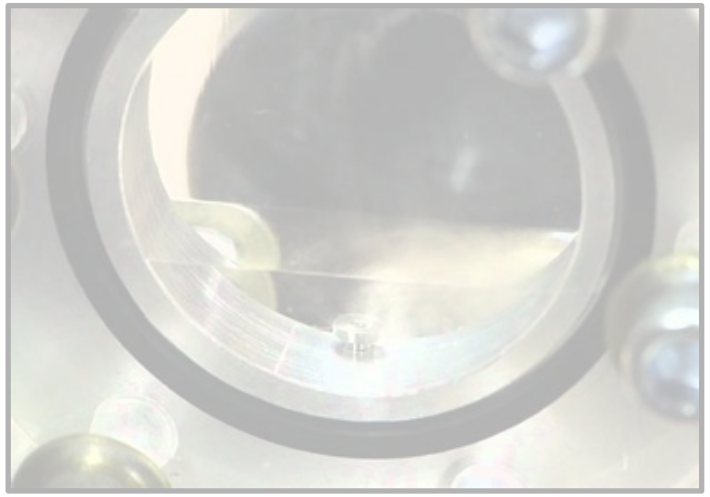
What limits scalability of existing carbon storage solutions?

Solid storage as carbonates

Solid storage as biochar



Subsurface pore space storage as supercritical CO_2

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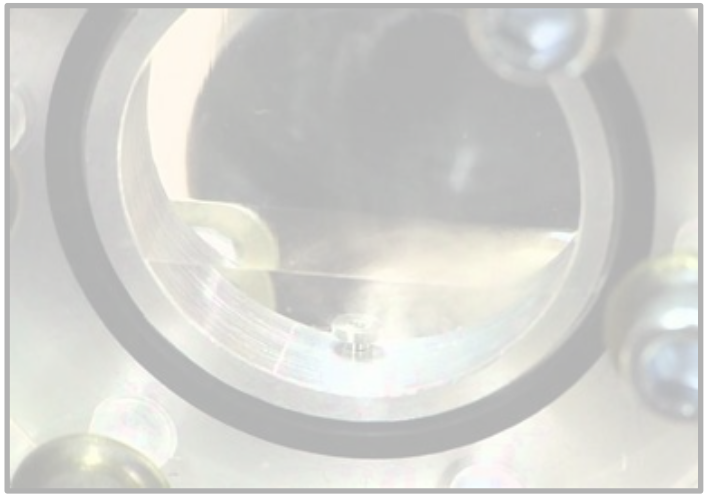

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What limits scalability of existing carbon storage solutions?

Solid storage as carbonates

$Ca+CO_2 \rightarrow CaCO_3$ *

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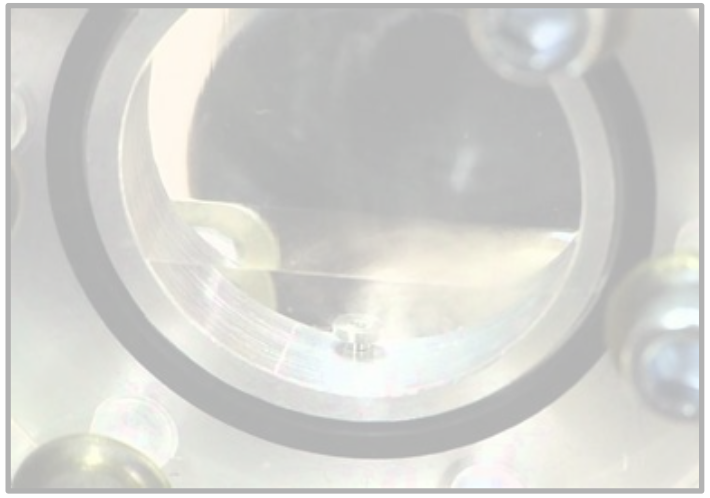

Subsurface pore space storage as supercritical CO_2

*balanced: $CaSiO_3+CO_2 \rightarrow CaCO_3+SiO_2$

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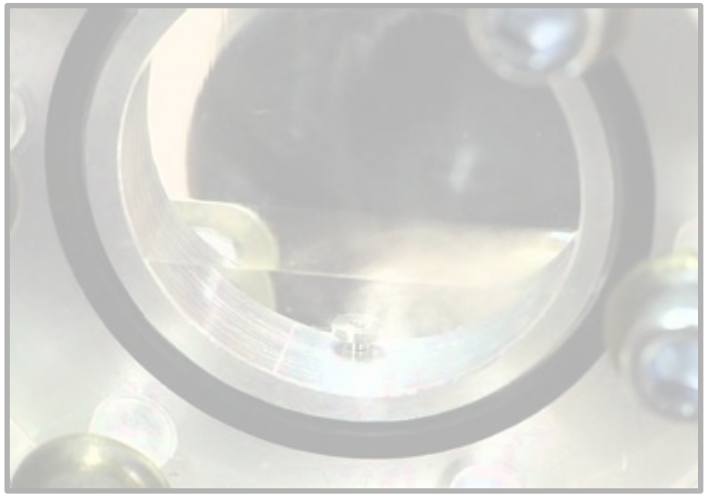

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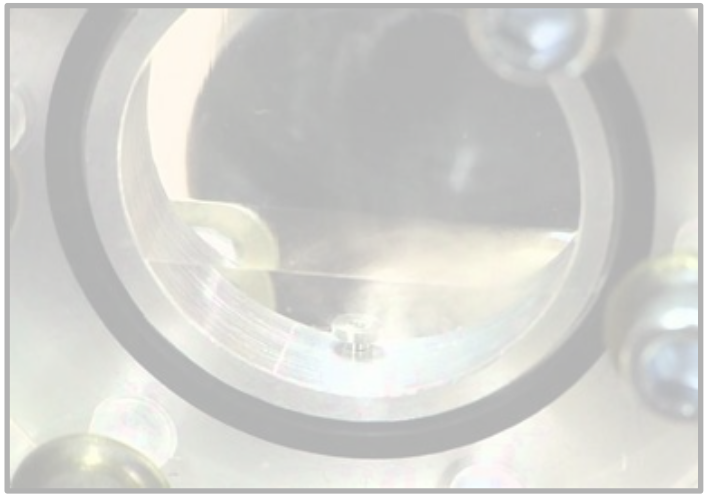

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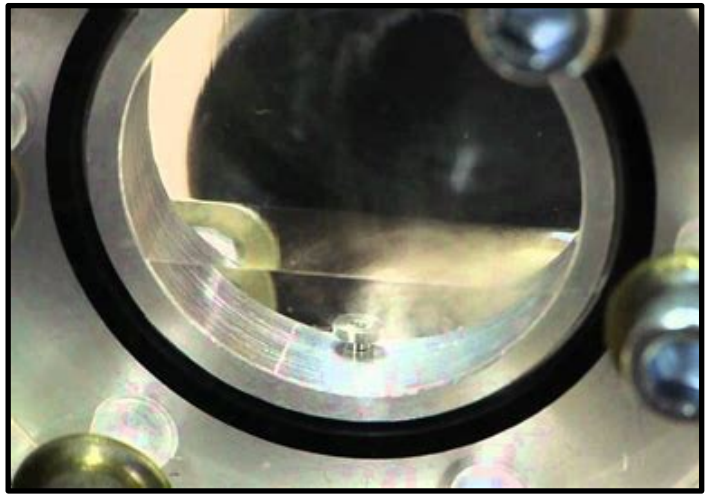

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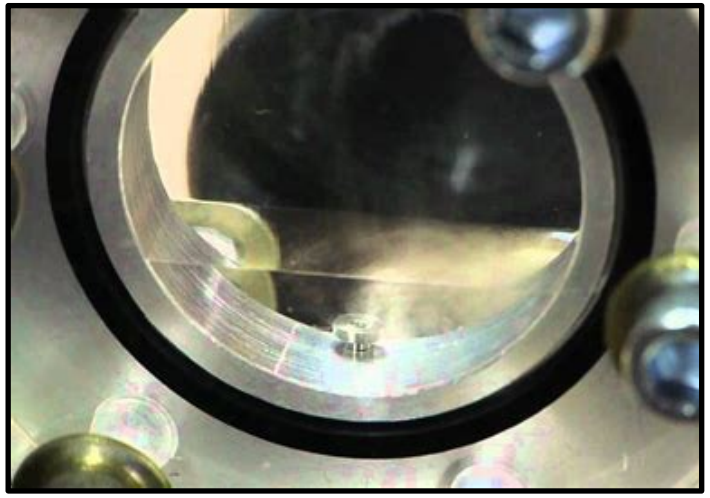

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Requires class VI wells

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Can we create “infinitely scalable” carbon storage?

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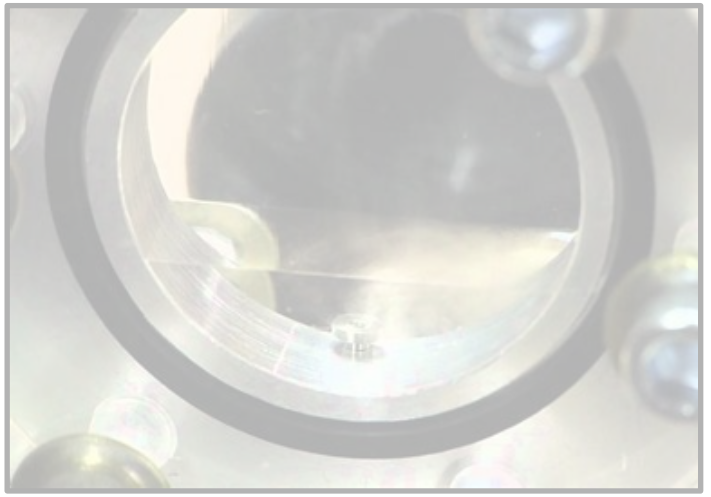

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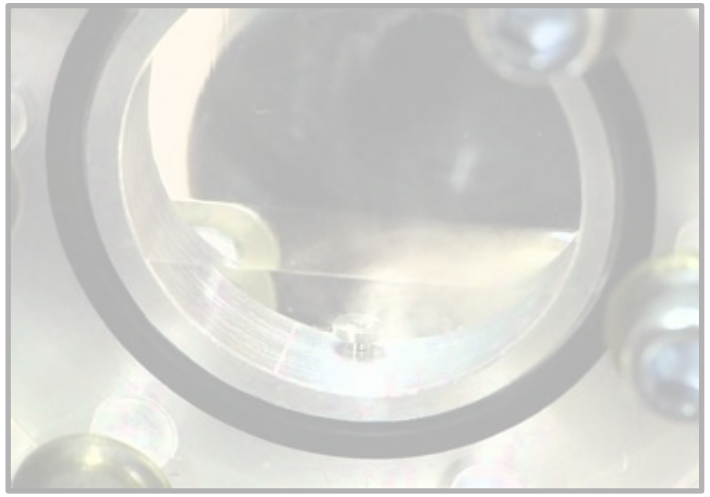

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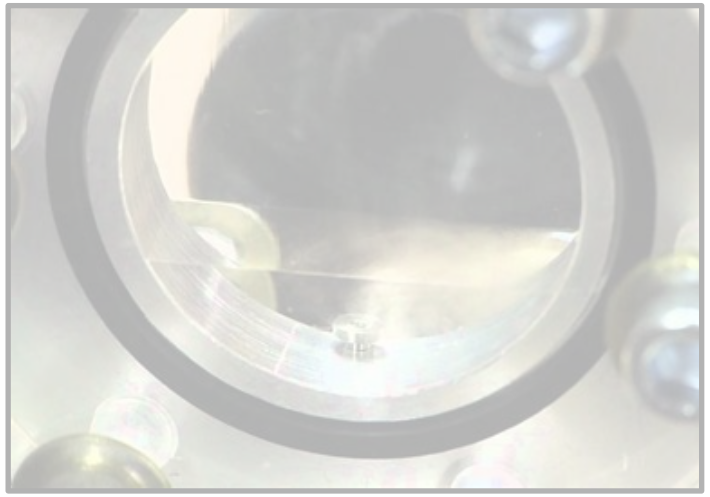

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No infrastructure/transport limitations

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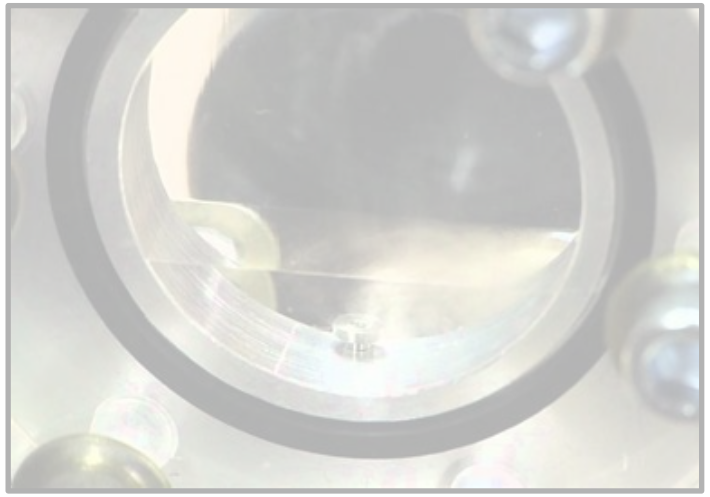

Subsurface pore space storage as supercritical CO_2

No stoichiometric mining requirements (Ca, Mg, P)

No infrastructure/transport limitations

No arable land requirements

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Let's think creatively about novel CO_2 to solid-phase carbon pathways.

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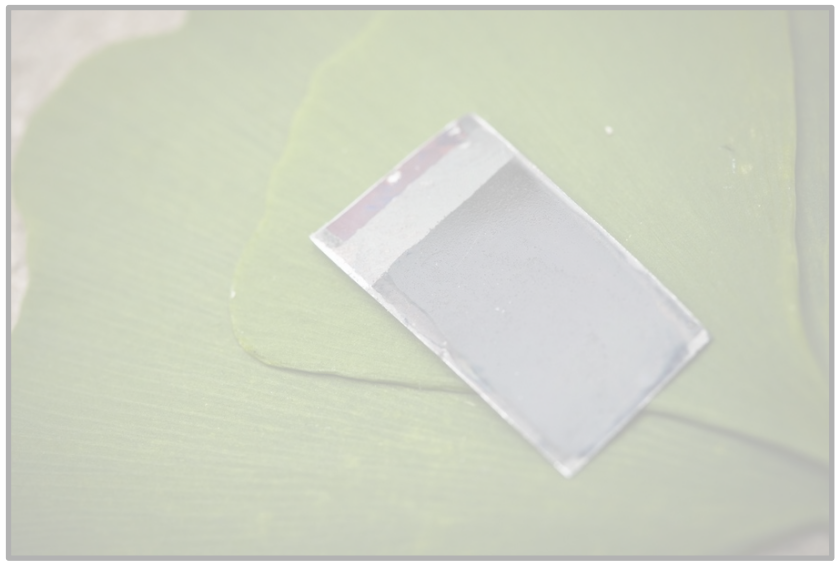
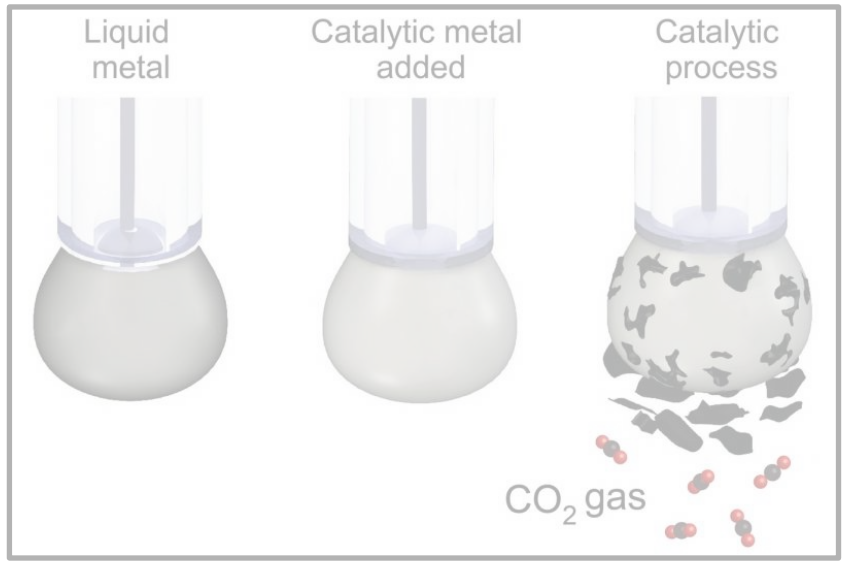


Nocera lab, MIT. Photo: Dominick Reuter



Dorna Esrafilzadeh *et al.*, Nature Communications, 2019. https://doi.org/10.1038/s41467-019-08824-8

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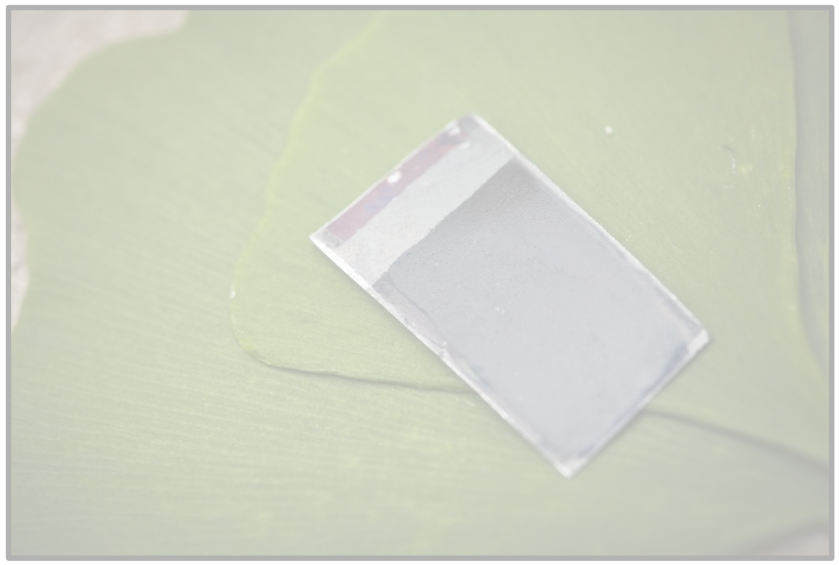

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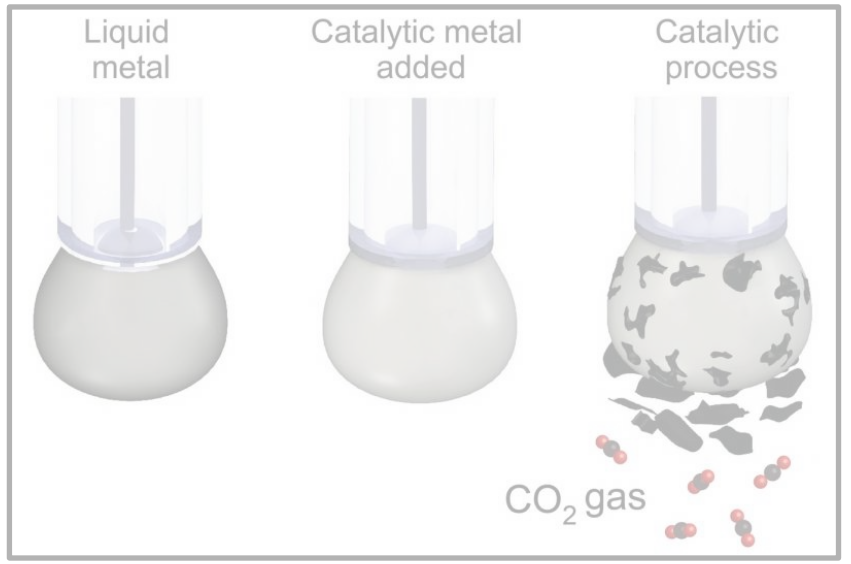

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Alternate minerals

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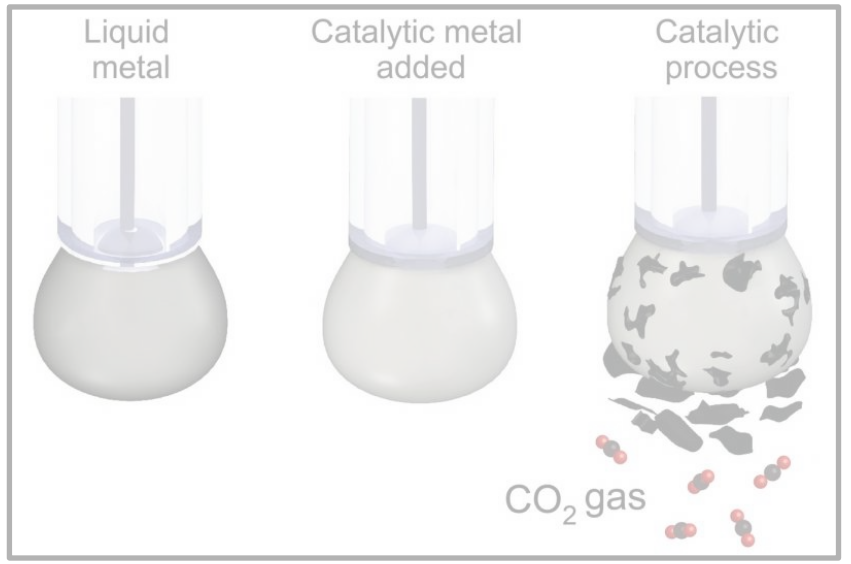

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Alternate minerals

Artificial photosynthesis

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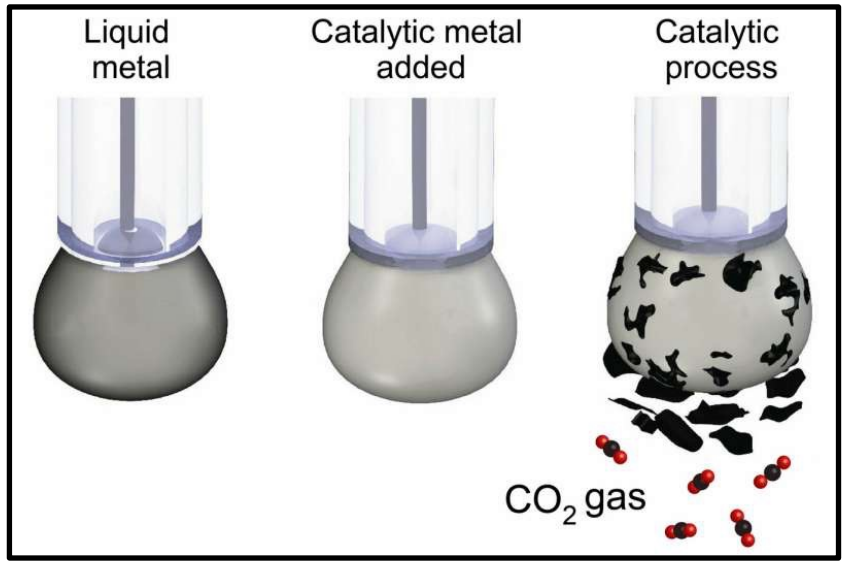

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Catalytic CO_2 to solid carbon

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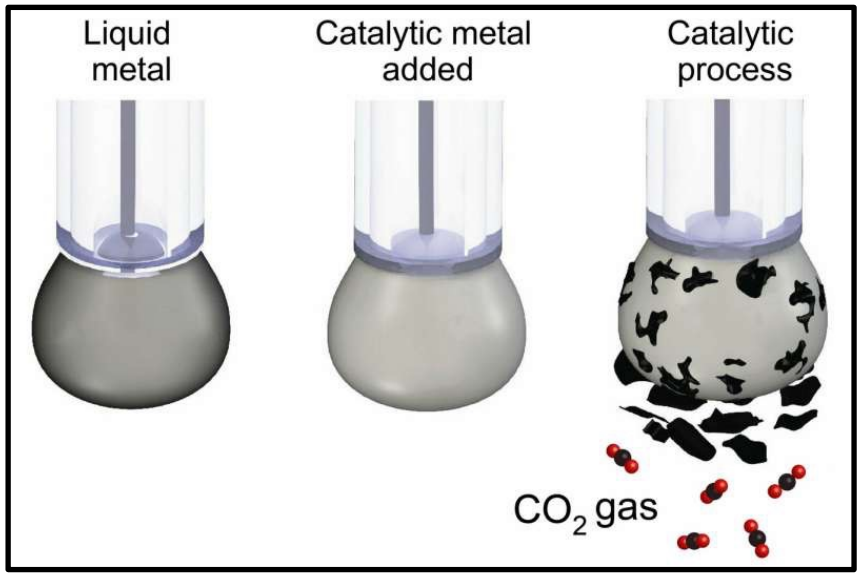

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Can we achieve carbon-containing compounds that are:

- energy- and emissions-efficient
- solid-phase
- permanent

Do you have ideas on how we can achieve "infinitely scalable" carbon storage? Let's talk!

elizabeth.troein@hq.doe.gov

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